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Comparisons of Musculoskeletal Complaints and Data Entry Between a Sitting and a Sit-Stand Workstation Paradigm

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Background: Seated working positions are often regarded as a cause for discomfort in the musculoskeletal system. Performing work in different working positions—that is, alternating between sitting and standing (sit-stand workstation paradigm)—could help reduce physical complaints. **Objective:** The questions were whether performing office work partly in a standing position leads to reduced complaints and whether standing would change the efficiency of data entry office work. **Method:** We investigated the effect of a sit-stand workstation paradigmd during experimental data entry office work on physical and psychological complaints and data entry efficiency by conducting a randomized controlled trial with 60 male participants ages 18 to 35 years. **Results:** In this experiment, musculoskeletal complaints were reduced by a sit-stand workstation paradigm. A trend could be identified indicating a small but nonsignificant loss of efficiency in data entry while standing. **Conclusion:** A sit-stand workstation paradigm reduces musculoskeletal complaints without considerably affecting data entry efficiency under the presented study conditions (young male participants, short duration, fixed and controlled sit-stand workstation paradigm, simulated experimental working condition). **Application:** According to the present data, implementing a sit-stand workstation paradigm can be an effective workplace health intervention to reduce musculoskeletal complaints. This experiment encourages further studies on the effectiveness of a sit-stand workstation paradigm. Experimental research and field studies that prove the reduction of complaints when introducing a sit-stand workstation paradigm in the workplace could be the basis for evidence-based recommendations regarding such interventions.

INTRODUCTION

Sedentary office work is linked to complaints with regard to the musculoskeletal system. Sixty percent of office workers complain of physical discomfort (An et al., 2001; Spyropoulos et al., 2007). Often work itself, particularly sitting work, is considered to be the cause of such discomfort (Juul-Kristensen & Jensen, 2005). Reasons for discomfort can be an unchanging sitting position (Manchikanti, 2000) and/or a general lack of movement (Korhonen et al., 2003).

Changing the organization of work to reduce the time spent in a sitting position without disrupting the work process is an attractive proposition. Reducing monotonous positions (e.g., sitting or standing) can curtail static muscle work and its narrow and negative impact on the musculoskeletal system (Aaras, 1987). Performing office work partly in standing positions is often recommended, as it is said to reduce complaints (Wilks, Mortimer, & Nylen, 2006).

It is assumed that standing or walking enhances cognitive performance, because upright positions activate the cardiovascular system (Watanabe, Reece, & Polus, 2007) and lead to increased stimulation and awareness (Caldwell, Prazinko, & Caldwell, 2003; Elliott et al., 2005). Standing at high desks or walking while

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engaging in memorization tasks has been recommended, as this not only positively affects the musculoskeletal system but also enhances cognitive performance (Bonnet & Arand, 1999; Dault, Geurts, Mulder, & Duysens, 2001).

However, as human cognitive processing resources are limited and scissile, the effectiveness of performing two tasks simultaneously can differ from that of performing a single task (Kahnemann, 1973; Navon & Gopher, 1979).

Performance scores on one or both tasks are often lower when tasks are performed simultaneously than when they are performed separately. This loss of performance is called *dual-task cost* (Pashler, 1994). In the case of dual-task costs, it is assumed that the tasks compete for the same sort of information-processing resources (Wickens, 1980). A highly automated task needs low information processing. Although highly automated tasks compete for the same resources, dual-task costs should be low given that few resources are taken up (Beilock, Carr, MacMahon, & Starkes, 2002; Beilock, Wierenga, & Carr, 2002).

Postural control has been considered a highly automated process and, therefore, consumes minimal attention and cognitive resources (Regnaux et al., 2005). However, a growing body of scientific work shows that maintaining postural stability requires considerable information-processing resources, which might in turn reduce performance on a second task (dual-task cost; Jamet, Deviterne, Gauchard, Vancon, & Perrin, 2007; Siu & Woollacott 2007; Woollacott & Shumway-Cook, 2002).

Office work can be mentally very challenging. Therefore, mental work that is partly performed in a standing position—for example, in a sit-stand workstation paradigm—might lead to reduced mental performance.

Apart from the potential occurrence of a dual-task cost, the mental task is interrupted by a short break when changing work positions. This break could lead to reduced efficiency or, alternatively, to improved cognitive performance because of activation of the cardiovascular system and increased stimulation and awareness.

The scientific interest of the present experiment concerns whether a sit-stand workstation paradigm reduces musculoskeletal complaints and whether it changes cognitive performance immediately or over time (1 week).

MATERIALS AND METHODS

Participants

Sixty male students from the University of Mainz in Germany ages 18 to 35 years were allocated randomly to an intervention and a control group. Participants had to fill in a medical history. Those who reported diseases and, particularly, problems with the central nervous system were excluded from the study. The questionnaire included questions on sleep duration, medication, and the consumption of alcoholic beverages, nicotine, and other drugs, as these factors are liable to alter postural control or cognitive processing. None of the participants was a professional with regard to data entry, nor were any of them touch typists. All participants had given written informed consent prior to the study. The study was approved by the local ethics committee.

Procedure

Office work was simulated, with a focus on data entry. The sit-stand workstation intervention group performed the data entry task in partly sitting (50% of the time) and partly standing (25% of the time) position. The control group completed the data entry task while seated (75% of the time). For the control group, a working hour of 60 min constituted 45 min of data entry in a sitting position, whereas the sit-stand workstation intervention group completed data entry in a sitting position for 30 min, followed by a 15-minute interval during which participants entered data while standing. The remaining 15 min for both groups were occupied with a 10-min period of non–data entry office work (such as photocopying, shredding, and sending faxes) and a 5-min break. This working cycle was repeated similarly each working hour. The office work had to be carried out 4 hr a day from 8:30 a.m. to 12:30 p.m. on 5 consecutive days.

For the data entry task, the participants received printed lists of names, numbers, and characters. Data sets were made up of 700 lines with four rows (consisting of numbers and characters)

and had been randomly generated using a special computer program. In a computer data entry input field, random numbers had to be allocated to the corresponding random names.

Data entry was conducted using a standard keyboard. Strings of numbers and characters varied in length between 5 and 11 characters. The length of the strings changed every hour. All participants had been instructed to correctly fill in as many numbers and characters as possible. The data volume was large enough that it could not be completed in the allocated time. The worktables were adjustable in height within seconds and without effort by a hydraulically controlled mechanism (Fa. Leuwico "go² move").

Measuring Instruments

The computer program counted the quantity and quality of numbers and characters entered into the computer. The results were automatically generated as a mean value for every 5-min period. Because of a programming mistake, the last 5 min of the data entry period (Minutes 40 to 45) were not saved, but the participants continued their data entry task during that period.

Group differences regarding psychological and physical well-being were tested with the use of two well-proven questionnaires: the Gießener Beschwerdebogen (GBB; Brähler, Hinz, & Scheer, 1995) and the Mehrdimensionaler Befindlichkeitsfragebogen (MDBF; Steyer, Schwenkmezger, Notz, & Eid, 1997).

The GBB was used as an indicator for physical complaints. For this purpose, the participants were asked to classify 24 single complaints (e.g., back pain, nausea, and dyspnea) on a scale ranging from 0 = *no complaints* to 4 = *severe complaints*. Six single complaints were merged in each of four sum scores (e.g., limb pain, stomach trouble). The sum score for limb pain, for example, consists of scores for the following 6 complaints: joint pain, backaches, neck and shoulder pain, headaches, feeling of heaviness in the limbs, and feeling of pressure in the head. The sum score for limb pain can therefore be a minimum of 0 and a maximum of 24. All 24 single-complaint scores can be merged into an overall complaint score ranging from 0 to 96. Therefore, low values represent low complaints, and high scores are indicators of severe complaints (Brähler et al., 1995).

The MDBF detects three dimensions of an individual's present psychological condition, focusing on (a) good or bad mood, (b) alertness or tiredness, and (c) calmness or agitation. For this purpose, the participants were asked to rate themselves in relation to 24 statements on a scale ranging from 1 = *do not feel at all* to 5 = *feel very strongly*. (For example, "At the moment, I feel tired": 1= *I do not feel at all tired*; 5 = *I feel very tired*). Three sum scores, each consisting of eight statements, can be calculated. For the calculation, some of the scores are inverted so that a score near zero for the sum score represents better mood, more alertness, and more calmness (Steyer et al., 1997).

Statistical Analysis

Statistical analyses were performed using SPSS 12.0 (SPSS, Inc., Chicago; Nie, Hull, & Bent, 2003). Apart from descriptive statistics, stem and leaf plots have been calculated as well as a test on normal distributions (Kolmogorov-Smirnow test).

In the present experiment, three main experimental findings are of interest: physical and psychological complaints and data entry efficiency. For both outcome measures, there are two defined groups: control and sit-stand workstation intervention (between-subjects effect) and repeated measures (within-subject effect). All outcome measures have several influencing factors, such as time of day, experimental day, or differences in baseline measurements.

The measurements of the physical and psychological complaint scores are ordinal scales, and the data entry efficiency instrument is an interval scale. This is the reason the outcome measures need to be treated differently. For the physical complaint score (GBB) and the psychological complaint score (MDBF), one set of statistical hypothesis testing was performed according to the following a priori assumptions: If group differences develop during the experimental week because of the sit-stand workstation intervention, they probably would not appear immediately but would increase during the week; therefore, after 5 days of the experiment, the effect was to be measured and group differences statistically tested (Mann-Whitney U test). All other time points have been evaluated post hoc (Mann-Whitney U test), and p values are not adjusted (refer to Table 1).

TABLE 1: Number of Keystrokes (KS) and Errors (E) per Minute and Error Rate (Percentage of Keystroke Errors per Minute) Measured in the First 5 Min (Baseline) of Data Entry Office Work (*n* = 30 per Group)

Variable and Group	*M*	Median	*SD*	Minimum	Maximum
KS/minute					
Control	35.1	36	8.6	20	48
Intervention	29.7	28	8.3	11	52
E/minute					
Control	0.8	0.2	1.7	0	9
Intervention	1.2	0.4	2.5	0	11
Error rate (%)					
Control	3.1	0.6	7.8	0	40.9
Intervention	6.3	1.2	18.6	0	100

The hypothesis testing for data entry efficiency was performed with a two-way analysis of covariance (ANCOVA), with repeated measures. This is possible because the data derive from an ordinal scale, they are normally distributed, and the variances are similar. ANCOVA is a statistical method that assumes a general lineal model, with one continuous outcome variable and one or more factors. In the present study, there are two main factors: group differences (two independent groups = between-subjects effect) and repeated measures (within-subject effect); therefore, it is called a two-way ANCOVA. ANCOVA is a fusion of ANOVA (analysis of variance) and regression for continuous variables. ANCOVA tests whether certain factors have an effect on the outcome variable after removing the variance for which quantitative predictors (covariates) account. In the present study, the individual means from the first 5-min data entry period were used as covariates in the statistical model, representing baseline differences (Crager, 1987; Pocock, Assmann, Enos, & Kasten, 2002; Vickers & Altman, 2001).

To determine time effects, group differences, and Group × Time interactions, we employed ANCOVA for the number of keystrokes per minute (20 time points = individual mean of a period of 35 to 40 min, 4 hr per day, 5 workdays). In the sit-stand workstation intervention group, at 30 min into the hour, participants adjusted the table from a sitting to a standing position. Furthermore, the 25- to 30-min and 30- to 35-min periods may have shown an artificial reduction in productivity because of the table adjustment. For the between-group comparison (sitting or control versus standing or intervention), we compared the 35- to 40-min period between groups. These time points represent a period in which the sit-stand workstation intervention group worked in a standing position and the control group in a sitting position.

RESULTS

Population

Both groups were similar in regard to socioeconomic and health data, such as those concerning sports, hobbies, family status, nationality, and consumption of drugs and alcohol. The sit-stand workstation intervention group, however, included 14 smokers, compared with 5 smokers in the control group. The mean age of the students in the control group was 24.7 (*SD* = 3.8), and in the sit-stand workstation intervention group, the mean age was 25.1 (*SD* = 2.7). All participants fulfilled the inclusion criteria and did not report any obvious physical or cognitive health problems.

Physical and Psychological Well-Being

Prior to the start of the experiments, as well as every morning before starting the experimental office work, both groups had similar questionnaire scores regarding physical and psychological well-being. However, on the basis of questionnaire scores measured after work, the sit-stand workstation intervention had a pronounced effect on physical well-being, represented by statistically significant group differences (Figure 1).

When we compared morning complaint scores against scores after work, both groups

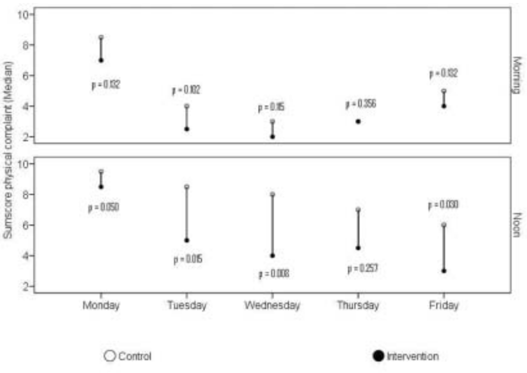

Figure 1. Median of physical well-being before and after experimental office work represented by the Gießener Beschwerdebogen total score. Median: control versus sit-stand workstation intervention. A priori hypothesis test: Friday noon. Post hoc: all other tests. α was not adjusted.

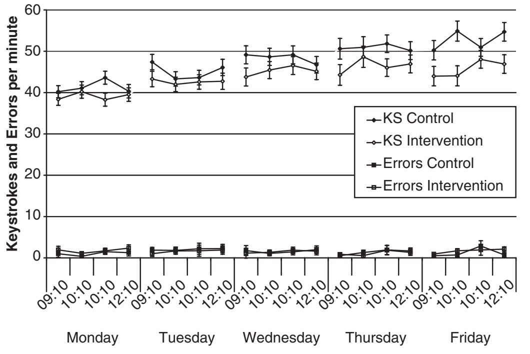

Figure 2. Mean values of the 35- to 40-min period of each experimental hour, representing a time interval in which the control group performed data entry in a seated position and the intervention group in a standing position. Displayed are the number of keystrokes per minute and the number of errors per minute, after removing baseline variances mathematically by ANCOVA. Error bars represent Standard Error of the Mean (SEM).

showed increasing complaints during the day, but by the next morning, there was recovery. In the course of the week, before and after data entry, complaint scores decreased in both groups.

Psychological well-being (mood) prior to the sit-stand workstation intervention (measured with the MDBF) was as follows in the control group: good or bad mood 31.9 (32.5) ± 4.9, alertness or tiredness 24.9 (25.0) ± 5.6, calmness or agitation 32.1 (31.5) ± 4.1. Numbers before brackets = mean. Numbers in Brackets = median. Numbers after "±" is Standard deviation. The MDBF questionnaire has three outcome sumscores. They are called good or bad mood, alertness or tiredness, and calmness or agitation. The numbers after the name of the sumscore belong to the respective sumscore (the number before the comma). There were no significant differences in mood scores between the control group and the sit-stand workstation intervention group prior to and after the week of work.

Data Entry Efficiency

There was a difference between the two groups with respect to the number of characters entered per minute. However, errors per minute and overall error rate did not differ (Table 1).

Data entry efficiency was different at the outset, but we expected an increasing difference, attributable to the sit-stand workstation intervention, to develop during the experimental time. This new developing group difference might be disguised by the group differences at the beginning. To visualize the potential new developing group difference, we performed covariance analysis to mathematically remove the variance accounting for the baseline difference (baseline adjustment; refer to Statistical Analysis; see Figure 2).

After we removed baseline variances, data entry efficiency differed little between the sitting and the standing data entry positions; all participants increased data entry speed during the experimental week. Mean data from each 35- to 40-min time interval of all 5 days were statistically analyzed to assess the impact of the two different ergonomic positions—sitting versus standing—on data entry efficiency. ANCOVA revealed a development over time (within-subject effect Greenhouse-Geißer p = .031), which is a learning curve. Group differences are significantly explained by the baseline covariance (p = .000). The ergonomic sit-stand workstation intervention (standing) did not contribute significantly to the between-subjects effect (p = .08).

Errors per Minute

The two ergonomic positions did not influence the number of errors per minute. During the 1-week data entry task, the incidence of errors did not change (Figure 2).

DISCUSSION

The aim of this experiment was to investigate whether a sit-stand workstation paradigm in an experimental work environment could affect physical and psychological well-being or data entry efficiency.

Physical and Psychological Well-Being

There were significantly fewer complaints after the working day in the sit-stand workstation intervention group compared with the control group. This is in accordance with previous investigations (Nakovics & Steiner, 1997). The experimental study by Nakovics and Steiner (1997) was not a randomized controlled trial. In their study, the groups differed in the occurrence of physical complaints and job characteristics, and use (frequency and duration) of the standing desk was not controlled. Therefore, it was of interest to consider findings that were in a more controlled setting and under more rigorous methodological conditions.

The physical complaint score is a validated method for the measurement of complaints. Brähler et al. (1995) investigated large representative reference groups. Their study participants voiced considerably fewer physical complaints prior to and after the study compared with the reference population of the test (GBB). All participants in the present trial were students. Self-reports of complaints have been found to vary in relation to a variety of factors, including age, gender, educational level, and situational factors (Brähler et al., 1995; Makela et al., 1991). With regard to some of these factors—for example, age and gender—the reference population of the applied complaint test is divided into subgroups.

However, there are no extra standard values for students, who work less compared to the normal referring age group (Brähler et al., 1995). The special features of the study cohort in the present experiment thus explain the relatively low level of physical complaints quite well. Financial incentives (remuneration of 200 per week), social factors, or inexperience with regard to the job requirements might also have affected self-reports. Most participants in the sit-stand workstation intervention group reported fewer physical complaints after 1 week's work than did those in the control group. The statistically significant group difference does not necessarily imply that there is a biological difference. The actual mean difference between the two groups is small but remarkable, given that the intervention was short.

In this randomized controlled trial, it cannot be ruled out completely that the control group was more sensitive to musculoskeletal complaints than was the sit-stand workstation intervention group. However, the groups did differ slightly but not significantly at baseline with respect to physical or psychological well-being (surveyed immediately before the start of the trial). After we take into account the baseline differences of the physical complaint score by calculating differences or percentages, the group differences after intervention disappear. Therefore, it can be assumed that the group difference can be at least partly attributed to the sit-stand workstation intervention. As the intervention was not blind, students in the sit-stand workstation intervention group might have assumed that they were expected to develop fewer complaints. This might have contributed to the group difference. However, if the group difference between the sit-stand workstation intervention group and the control group existed only because of a lack of blinding, there would be an effect on the psychological well-being, as the students would have anticipated that they were supposed to be in a better mood or more awake as well. However, there are no significant group differences with respect to psychological well-being before and after the sit-stand workstation intervention (Sibbald & Roland, 1998).

Because mood or psychological well-being depends strongly on the specific situation, to compare different situations (for example, comparisons with a reference population) is of only limited relevance (Steyer et al., 1997). Therefore, in this study, the psychological mood scores were not compared with those of a reference population. It was nevertheless interesting to conduct randomized controlled trials, as they enabled us to compare the psychological state and mood of two similar groups. These two groups experienced the same situation, except that one group was exposed to the trial sit-stand workstation intervention and the other group was not exposed.

In this trial, there were no differences between the two groups before and after sit-stand workstation intervention. This is contrary to findings in other literature that show differences in psychological well-being depending on the ergonomic position (Argiropoulos & Seidel-Fabian, 2002). Although the literature cited refers to trials with users of stand-up tables, no randomized controlled trials have been found that investigate the relationship between the sit-stand workstation paradigm and mood changes.

Efficiency

Data entry efficiency was only marginally influenced by the sit-stand workstation intervention. No significant group differences could be found in relation to the sit-stand workstation intervention, but a small trend toward decreased efficiency during standing was shown. This is in accordance with several other studies on young adults performing a cognitive task that report no occurrence of dual-task cost while standing (Jamet et al., 2007; Lindenberger, Marsiske, & Baltes, 2000; Marsh & Geel, 2000; Redfern, Jennings, Martin, & Furman, 2001).

These were experiments on the immediate effect of standing compared with other positions. Measurement of data entry efficiency in step with actual practice at work for a period longer than mere minutes had not been found in the literature until now. There was no confirmation of the presumption that sit-stand workstation use would increase cognitive performance.

The question of whether fewer complaints attributable to the sit-stand workstation intervention might have positive effects on cognitive performance in the long run (fewer complaints = reduced distraction and fewer sick days) cannot be answered through the present experiment; to answer that question would require an experiment that is performed across longer spans of time.

Learning

Both groups clearly showed increased keystrokes per minute over time, most likely attributable to a learning process.

Because dual-task cost can be reduced by automation or learning, it would be interesting to know whether dual-task cost appeared at the beginning and disappeared after a learning process. This process might not be clearly visible when one is working with experienced data entry professionals who demonstrate high levels of automation. Therefore, the learning curve was intended and was an important part of the experimental study design.

Across a longer period (1 week), data entry efficiency was not influenced by the sit-stand workstation intervention. There was no enhanced learning during work while standing; learning seemed to be rather less effective over time. This is not in accordance with previous literature, which states that dual-task training leads to better dual-task performance (Pellecchia, 2005; Ruthruff, Van Selst, Johnston, & Remington, 2006). It could therefore be assumed that an effect occurred that is unrelated to the effect of dual-task cost.

Simulated Data Entry Office Work

Entering text and data into a computer, operating a variety of office machines, and performing other clerical duties are the daily labor of data entry and information-processing workers. In 2004, 525,000 jobs in the United States spread across every sector of the economy were filled by data entry and information-processing workers (Bureau of Labor Statistics, 2008-09).

In this study, some of the psychological, mental, and physical aspects of data entry office work were simulated, and the resulting psychological and physical strain, as well as data entry efficiency, were measured. Because of the instruction to enter the data as quickly and as correctly as possible, time pressure emerged. Time pressure was enhanced by the fact that the given amount of data to be entered could not be accomplished in the allocated time. Entering data under such conditions is a realistic job requirement. The data that have to be entered are often incoherent or meaningless figures, such as credit card numbers. Entering random numbers into a computer is therefore similar to the usual day-to-day job of a clerical worker.

Two characteristics of data entry are important to determine its efficiency: speed of entry and the occurrence of errors. The speed of data entry in the study was about 30 keystrokes

per minute at the beginning of the experiment and increased by 15 characters per minute during the 5-day period. The speed of data entry was very low compared with that of professional data entry operators, who are able to make 130 keystrokes per minute (Galinsky et al., 2007). One explanation for this finding might be that the students in this study were not professionally occupied with data entry and did not use touch typing but, rather, a two-finger system for data entry. Were they to have several years of experience and the ability to touch type, their number of keystrokes per minute would probably increase.

The error rate of 3% to 6% (Table 1) in this study is very high compared with the error rates usually reported in other investigations (Neaton, Duchene, Svendsen, & Wentworth, 1990). This might be because study participants were inexperienced and did not get feedback on their data entry performance, contrary to what would be the case in a real job environment.

Study Design

In the present experimental study, a randomized controlled trial was applied. A randomized controlled crossover design had been discussed, but for methodological and organizational reasons, it was not selected.

Three basic prerequisites are crucial when applying a crossover design in experimental studies. First, there should be no carryover effects. The present data suggest that there was a steep learning curve in the data entry task during the 5 days of the experiment. There is no recovery from one day to the next; hence a carryover effect is likely. With regard to data entry efficiency, a crossover design was not applicable. The psychological and physiological outcomes have a more transient nature, and with a crossover design with a break of a couple of weeks, potential carryover effects might be eliminated.

Second, the medical or physical condition treated should not be permanently influenced by the treatment. It is unlikely that musculoskeletal complaints would be permanently reduced by a sit-stand workstation paradigm. The present data show differences in the complaint scores between sit-stand workstation intervention and control concerning adaptations to the work during the course of the week. Recovery occurs from one day to the next, but this recovery is not complete, and therefore carryover cannot be excluded.

Third, the condition treated has to be stable (must not change over time by chance or because of the nature of the condition). The present data show adaptations in the complaint score during the experimental week, and the musculoskeletal complaints therefore cannot be considered stable (Higgins & Green, 2006).

In the present study, a crossover design might be helpful for reducing interindividual variance and sample size. Instead, because of the described disadvantages of such designs, a larger sample size and ANCOVA were applied to cope with interindividual variances (Roberts & Torgerson, 1999; Sheikh, Smeeth, & Ashcroft, 2002). In spite of the advanced study design, it cannot be completely ruled out that the present group differences after sit-stand workstation intervention were the consequence of group differences at baseline. A crossover design might have provided more certainty in that point.

Before one spends any effort on introducing or recommending sit-stand workstation paradigms or on conducting longer studies under real working conditions, it is of interest to see if there are any effects under very controlled conditions. Similar to drug efficiency studies, in which the intake of the drug is well controlled, it is known that treatment compliance under real-life conditions can be very different for several reasons. Reasons for noncompliance, for example, are side effects or absence of treatment effect.

In previous studies, there was poor compliance with the sit-stand workstation paradigm in long-term investigations (Wilks et al., 2006).The present study was designed to contribute information concerning the question, Why is there poor compliance? Is it because there is no immediate effect, or no effect at all, on discomfort? Is it because people perceive limited (cognitive) performance in terms of side effects?

Our data show that there is an immediate effect on musculoskeletal complaints, and side effects, particularly, reduced cognitive performance,

appeared only to a limited degree. The present data therefore do not explain the poor compliance in the application of sit-stand workstation paradigms of previous studies. Therefore, the reasons for noncompliance seem to be related not to nonexisting immediate effects or side effects but, rather, to behavioral issues, which cannot be addressed in a 1-week experimental trial. The duration of the experimental work (only 4 hr per day for 1 week) is too short to understand completely the impact of sit-stand workstation paradigms on the development of musculoskeletal complaints in working life. Therefore, clinical trials with longer durations and that are more focused toward improving compliance seem interesting and necessary, and the present data support such an effort.

Sit-Stand Workstation Paradigm

To reduce the amount of static sedentary posture during data entry, dynamic sitting (changing sitting positions on a chair) or a sit-stand workstation paradigm can be introduced. These are only two of several possibilities in a work setting. Others are breaks, changes regarding work requirements, and a reduction of working time to reduce the amount of monotonous sedentary work.

One advantage of a sit-stand workstation paradigm is that data entry work can continue. There are possibilities for applying a sit-stand dynamic. For example, workers could stand whenever they want to, and it is possible to implement obligatory time schedules. Having the choice of whether and how often to change working position can itself affect perceived musculoskeletal complaints and mood (Argiropoulos & Seidel-Fabian, 2002). These changes in physical and psychological well-being could also be induced by other degrees of freedom at work or care for the employee. As a means to learning something about the ergonomic benefits of the sit-stand dynamic, which was the goal of this experimental study, a fixed obligatory time schedule seems preferable.

Presumably, different time regimes implementing standing work periods in a predominantly sitting working day can be differentially effective. In this study, the protocol was arranged according to the recommendations of the BAUA (German Federal Institute of Occupational Medicine and Work Safety). We could have rotated sitting and standing periods more often over time to introduce more dynamic movement, which might have had a greater effect on musculoskeletal and/or psychological well-being but also might have had a negative effect on data entry efficiency. It would be interesting if further studies included different time schedules to investigate dose–effect relationships and any causal chain between the ergonomic modification and a reduction in complaints and to discover the most effective time schedules for implementation in actual working life.

A sit-stand workstation paradigm can be introduced as a way to address musculoskeletal complaints or as primary preventive activity before problems arise. In this study, the primary preventive strategy was chosen; therefore, a young, nonprofessional sample was selected for whom existing musculoskeletal problems were unlikely. The influence of a sit-stand workstation paradigm on elderly people already concerned with musculoskeletal pain could be different from the present findings. Therefore, special intervention studies are needed.

Limitations of the Study

The study was not blind; the participants were young male students only; and the intervention was short, only 4 hr a day of activity for 1 week. Therefore, the results can be generalized only to a limited degree. The data could be very different in other study populations, such as older participants, females, or people already suffering from musculoskeletal complaints. The present data are not transferable to those populations. Different outcomes also might result if the intervention were to be introduced for a longer period or if different sit-stand timing protocols were to be applied. Further experimental and clinical studies addressing the possible differences with regard to age, gender, educational level, duration of work, and different sit-stand timing protocols are needed.

This is nevertheless the first randomized controlled trial evaluating the influence of a sit-stand workstation paradigm on musculoskeletal and psychological complaints and data entry efficiency.

CONCLUSIONS

The study shows that a sit-stand workstation paradigm across a 1-week period in an experimental environment reduced musculoskeletal complaints without leading to considerably reduced efficiency in data entry. We therefore encourage further studies introducing a sit-stand workstation paradigm. Experimental research and field studies that prove the reduction of complaints when introducing a sit-stand workstation paradigm in the workplace could constitute a basis for evidence-based recommendations regarding such interventions.

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